EXPERIMENTS IN THE TREATMENT OF PLANT DISEASES.

By B. T. GALLOWAY.

(Plate IV.)

PART III.

In addition to the field work conducted in 1890 by the Division of Vegetable Pathology and set forth in Parts I and II of this article, a series of experiments were made under our direction by field agents located in various parts of the Union. The reports of these agents have all been received, and while it is our usual custom to publish them in the form of a special bulletin several reasons make it more desirable to give them in a condensed form here.

TREATMENT OF GRAPE DISEASES.

These experiments were carried on at Greenville, South Carolina; Vineland, New Jersey; and Neosho, Missouri. The work in the main was planned to throw additional light on the treatment of black rot, which is everywhere recognized as being the most destructive of all grape maladies. The questions we were desirous of obtaining more information upon may be briefly summarized as follows:

I. A comparison of the fungicides given below as regards cost, efficiency, and effects on the healthy foliage and fruit.

(*a*) Bordeaux mixture prepared in accordance with the usual formula, *i. e.*, copper sulphate 6 pounds, lime 4 pounds, and water 22 gallons.

(*b*) Bordeaux mixture prepared the same as *a*, then allowed to settle. After this has taken place drawing off the clear liquid and drying the sediment the latter being simply mixed with water when used. The object in using this preparation was to determine if possible whether the Bordeaux mixture prepared in advance was as effective as that made in the usual way. The question has considerable practical importance as there is an increasing demand for a mixture ready for use. This demand is mostly from small growers who do not care to go to the trouble of buying the copper and lime and making their own mixture.

(*c*) Modified eau celeste containing copper sulphate 4 pounds, aqua ammonia 3 pints, carbonate of soda 5 pounds.

(*d*) Copper carbonate in suspension, 3 ounces to 22 gallons. This being a much cheaper preparation than the ammoniacal copper carbonate solution, it was thought best to give it a thorough trial.

(*e*) Simple milk of lime made by dissolving 3 pounds of lime in 25 gallons of water.

(*f*) Solution of copper acetate, 2 pounds to 22 gallons.

(*g*) Mixture No. 5 consisting of equal parts of ammoniated copper sulphate and ammonia carbonate. Used at the rate of 1 pound to

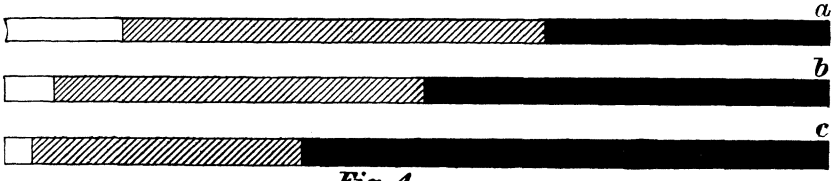

Fig. 4.

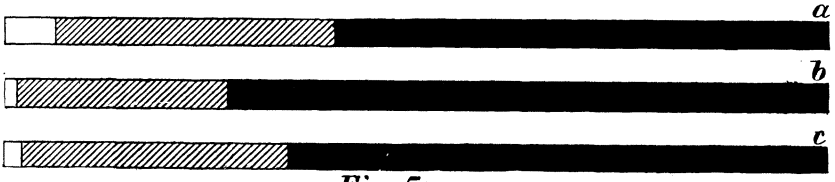

Fig. 5.

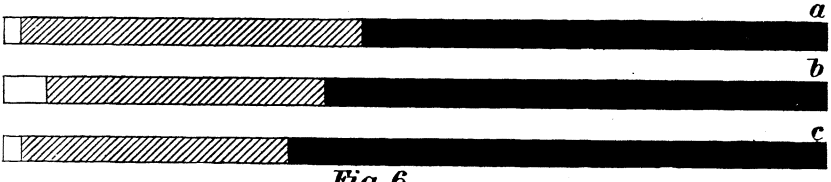

Fig. 6.

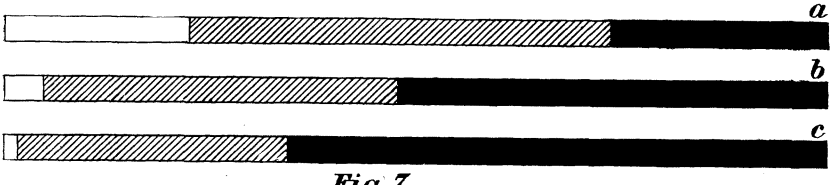

Fig. 7.

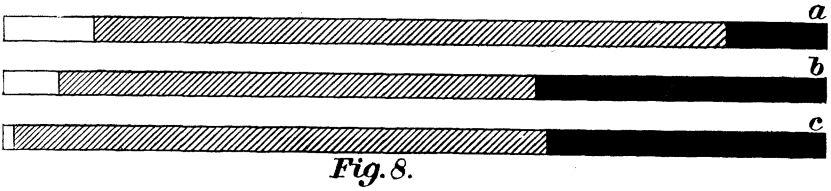

Fig. 8.

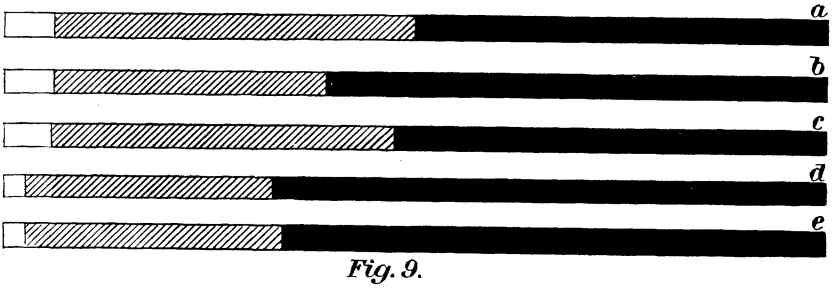

Fig. 9.

25 gallons of water. Mixture No. 5 is practically eau celeste in dry concentrated form.

(*h*) Ammoniacal copper carbonate solution, 3 ounces copper carbonate dissolved in 1 quart of ammonia, and diluted with 22 gallons of water.

II. The value of a mixed treatment, consisting of three early treatments of the Bordeaux mixture and three late sprayings of the ammoniacal solution.

III. The value of early against late sprayings. By early is meant the first treatment when the buds begin to swell, and by late the first treatment when the grapes are the size of bird shot.

EXPERIMENTS AT GREENVILLE, SOUTH CAROLINA.

The work at this place was conducted A. M. Howell, who is to be commended for the care devoted to it. The vineyard chosen by Mr. Howell for the experiment was one which had been well cultivated and cleared, but had never before received any treatment for vine diseases and for 3 years had regularly lost from 50 to 75 per cent of its crop by black rot. Besides this it had been invaded by downy mildew and anthracnose.

The variety selected for experimental treatment was the Concord, because of its regular habits of growth and fruitage, and its unvarying susceptibility to rot. In accordance with instructions the vineyard was divided into 14 contiguous plats, 11 consisting of 58 and 3 of 50 vines each. In the 11 plats, containing 58 vines each, a sub-plat of 8 vines was marked off in the center of each. These sub-plats were left without treatment. The vineyard was then divided as follows: Three plats of 50 vines each, containing no sub-plats; eleven main plats containing 50 vines each having in the center a sub-plat of 8 vines each. The different plats were designated by the letters of the alphabet from A to W, inclusive, as shown in the following diagram:

<table>
<tr><td>A</td><td>B</td><td>A</td></tr>
<tr><td>C</td><td>D</td><td>C</td></tr>
<tr><td>E</td><td>F</td><td>E</td></tr>
<tr><td>G</td><td>H</td><td>G</td></tr>
<tr><td>I</td><td>J</td><td>I</td></tr>
<tr><td>K</td><td>L</td><td>K</td></tr>
<tr><td>M</td><td>N</td><td>M</td></tr>
<tr><td>O</td><td>P</td><td>O</td></tr>
<tr><td>Q</td><td>R</td><td>Q</td></tr>
<tr><td>S</td><td>T</td><td>S</td></tr>
<tr><td>S</td><td>T</td><td>S</td></tr>
<tr><td colspan="2">U</td><td>U</td></tr>
<tr><td colspan="2">V</td><td>V</td></tr>
<tr><td colspan="2">W</td><td>W</td></tr>
</table>

FIG. 1.

The variation in regard to these was for the purpose of bringing out the value of early spraying, as will be shown later.

The first spraying was made 10 days before blooming, and would have been applied earlier but for a delay in the arrival of some of the chemicals. The weather had been dry for 2 weeks and no disease was showing on the leaves. The next day, however, a rainy spell set in, lasting 5 days. The second treatment was also given on a clear day and the first traces of black rot had been discovered the day before. There were rains on May 18, 19, 20, and then none until June 1. The day after the fourth treatment there was a light rain (June 15) and this was followed by a drought which put an end to any infection of black rot for the season.

In order to get a fair estimate as to the value of the various treatments the diseased and healthy berries on both the treated and untreated plats were carefully counted and weighed. The weight of diseased fruit was estimated by counting, in several cases, the number of berries in a pound of sound fruit, obtaining an average number, and dividing the number of diseased berries by it. The results of this work is shown in tabular form below.

Plat.	Number of vines, date, and manner of treatment.	Yield of sound fruit per plat.	Average yield per vine.	Number of rotten berries per plat.	Number of rotten berries per vine.	Total rot per plat in pounds of sound fruit.	Percentage of loss.	Total cost of treatment.
		Pounds.	*Pounds.*					*Cents.*
A	50 vines treated April 30, May 15 and 30, and June 14, with Bordeaux mixture	260	5.20	275	5.50	1.56	.6	.54
B	8 untreated vines	23	2.87	2,464	308	14	38	.00
C	50 vines treated April 30, May 15 and 30, and June 14, with ammoniacal copper carbonate solution	255	5.10	236	4.72	1.34	.6	.22
D	8 untreated vines	20	2.50	2,816	352	16	45	.00
E	50 vines treated April 30, May 15 and 30, and June 14, with Bordeaux mixture and ammoniacal solution	255	5.10	188	3.76	1.06	.4	.40
F	8 untreated vines	20	2.50	2,827	353	16	45	.00
G	50 vines treated April 30, May 15 and 30, and June 14, with modified eau celeste	260	5.20	68	1.36	.33	.1	Not given.
H	8 untreated vines	24	3	2,466	308	14	37	.00
I	50 vines treated April 30, May 15 and 30, and June 14, with copper carbonate in suspension	246	4.92	268	5.36	1.52	.6	.11
J	8 untreated vines	18	2.25	2,998	375	17	48	.00
K	50 vines treated April 30, May 15 and 30, and June 14, with milk of lime	190	3.80	8,599	172	48.86	20	.03
L	8 untreated vines	20	2.50	2,819	352	16	45	.00
M	50 vines treated April 30, May 15 and 30, and June 14, with Bordeaux mixture prepared in advance	230	4.60	367	7.34	2.08	.9	.54
N	8 untreated vines	22	2.75	2,126	266	12	35	.00
O	50 vines treated April 30, May 15 and 30, and June 14, with Bordeaux mixture, one-half strength prepared in advance	180	3.60	8,730	174.60	49.60	21.50	.27
P	8 untreated vines	17	2.12	2,372	284	13	43	.00

Plat.	Number of vines, date, and manner of treatment.	Yield of sound fruit per plat.	Average yield per vine.	Number of rotten berries per plat.	Number of rotten berries per vine.	Total rot per plat in pounds of sound fruit.	Percentage of loss.	Total cost of treatments.
		Pounds.	*Pounds.*					*Cents.*
Q....	50 vines treated April 30, May 15 and 30, and June 14, with acetate of copper solution.....	260	5.20	277	5.54	1.57	.6	Not given.
R....	8 untreated vines.....	20	2.50	2,176	272	12	37.50	.00
S....	50 vines treated April 30, May 15 and 30, and June 14 with mixture No. 5.....	255	5.10	113	2.23	.63	.25	Not given.
T....	8 untreated vines.....	25	3.12	2,472	309	14	36	.00
S'....	50 vines treated April 30, May 15 and 30, and June 14 with mixture No. 5.....	216	4.32	312	6.24	1.77	.8	Not given.
T'...	8 untreated vines.....	22	2.75	2,287	286	13	37	.00
U....	50 vines treated May 17 and June 2 with Bordeaux mixture; late treatment.....	210	4.20	2,112	42.24	12	5	.22
V....	50 vines treated May 25, June 9, with Bordeaux mixture, 8 days later than U.....	200	4	2,040	40.80	11.59	5.50	.27
W...	50 vines treated May 17 and June 2 same as U, excepting ammoniacal solution was used.....	220	4.40	2,618	52.36	15	6	.11

Very little comment upon the foregoing table is necessary, as we believe it fully explains itself and in a measure answers the questions summarized in the first part of this article. It will be seen that seven of the fungicides used reduced the amount of rot to less than 1 per cent, while on the untreated vines the loss averaged 40 per cent. This was much less than in an ordinary season, on account of the dry weather. In such cases about 75 per cent would have probably been lost. The present season was not one either that furnished a good test of fungicides. If more rain had fallen there is little doubt that there would have been more rot on the treated plats, more striking differences in the degrees of efficacy of the different fungicides, and more grapes actually saved. That is, the difference between the amount lost on the treated and untreated plats would have been much greater.

As to the comparative value of the fungicides, the ratios found in the figures as given can scarcely be considered such as will hold for other seasons and in different climates. This season's work has shown that a difference in locality affects the action of fungicides on foliage; for example, the copper acetate, which proved very efficacious with Mr. Howell, of South Carolina, burned the foliage so badly in Missouri as to ruin the crop for the year.

Milk of lime and precipitated Bordeaux mixture, one-half strength, both proved ineffectual. As regards efficiency the other fungicides stood in the following order:

Modified eau celeste.
Mixture No. 5.
Bordeaux mixture and ammoniacal solution.
Bordeaux mixture.
Copper acetate.
Ammoniacal solution.
Copper carbonate in suspension.
Precipitated Bordeaux.

The loss from not beginning the treatments early was not as striking as was anticipated, but there is no doubt that a wet spring would have shown a more decided contrast between the effects of late and early treatments. As it was, a difference of 8 days in the date of the first application made a difference of 5 per cent in the amount of rot, showing that it is not safe to begin treatments later than the last of April in the Southern grape-growing districts, or, in general, about 10 days before the blooming.

EXPERIMENTS AT CHARLOTTESVILLE, VIRGINIA; VINELAND, NEW JERSEY; AND NEOSHO, MISSOURI.

The experiments at the foregoing places cover practically the same ground as those given in detail in the preceding notes; in fact, the same plan was followed at each place. Without going into further details, for which we have not space here, the entire work may be summarized as follows:

I. All things considered, the Bordeaux mixture still heads the list as a preventive of black rot.

II. The Bordeaux mixture prepared in advance according to the directions already given is not satisfactory, and is therefore not worthy of further use.

III. Copper carbonate in suspension and milk of lime are comparatively useless as preventives of black rot and other grape diseases.

IV. Copper acetate has fungicidal value, but in most sections it is likely to injure the foliage.

V. The cheapest and most effectual remedy for black rot and downy mildew, taking everything into consideration, is the ammoniacal solution of copper carbonate. Next to this is a mixed treatment consisting of two or three early sprayings of Bordeaux mixture and the same number of late treatments with ammoniacal solution.

VI. Mixture No. 5, while possessing value as a fungicide, is likely to injure the foliage. Until this difficulty is overcome its use on a large scale can not be recommended.

VII. Early sprayings are absolutely necessary to insure the best results in the treatment of black rot.

As heretofore, experiments in the treatment of a number of plant diseases were carried on under our direction in Wisconsin by Prof. E. S. Goff, of the State Experiment Station. Following is Professor Goff's report in full.

TREATMENT OF FUNGOUS DISEASES.

REPORT OF E. S. GOFF, MADISON, WISCONSIN.

SIR: I have the honor to report the results of experimental work in the treatment of certain fungous diseases of plants as per plan approved by you in May last.

E. S. GOFF,
Special Agent, Madison, Wisconsin.

Mr. B. T. GALLOWAY,
Chief of the Division of Vegetable Pathology,
U. S. Department of Agriculture.

The fruit farm of Mr. A. L. Hatch, on which the experiments here reported were conducted, lies 3¼ miles southeast of the village of Ithaca, Richland County, Wisconsin. It crowns the summit of a hillock, and is not far from 1,000 feet above sea level. The soil is a light clay loam, underlaid by Potsdam Sandstone, and is in a good state of cultivation.

The plan of work arranged included treatment for the apple scab, *Fusicladium dendriticum*, Fckl., the Septoria of the raspberry and blackberry, *Septoria rubi*, West, and the potato rot. The weather during the early summer, however, proved excessively rainy,* and the effects of some of the applications were undoubtedly destroyed by copious showers soon after the treatments. It was sometimes necessary to postpone applications from day to day owing to the very frequent rains. The somewhat meager results secured in the treatment of apple scab, as compared with the season of 1889, are probably attributable to the excessive rainfall of the early part of the summer.

In all of the experiments the spraying was performed with the so-called "Little Climax" force pump, fitted with the Nixon nozzle. The Vermorel nozzle was tested for applying the Bordeaux mixture, but was little used, as the Nixon nozzle was satisfactory. The liquids were always applied in sufficient quantity to pretty thoroughly wet the foliage.

EXPERIMENT IN THE TREATMENT OF APPLE SCAB.

The fungicides tested the past season for preventing apple scab were:

I. Copper carbonate dissolved in ammonia, as used in 1889, and also suspended in water.

II. The sulphur powder, so called, tested in 1889, and introduced by Mr. E. Bean, of Jacksonville, Florida.

III. The compound of ammoniated copper sulphate and ammonium carbonate furnished by your department as Mixture No. 5.

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* No systematic meteorological records were kept at Ithaca during the early part of the season, but the following notes were made by Mr. Hatch: "Heavy rain May 9, 10, and 12; May 31, rains since the 13th, severe and frequent; rain June 3, 4, and 5; June 15, rained heavily almost every day or night since the 7th; June 18, hard rain; June 29, heavy rain June 20, 21, 22, 23, and 24, thunder on the 24th, very hot since the 23rd, 90° to 95° several days, with very humid atmosphere, more rain on the 29th; July 11, very heavy rain; July 13, rain with wind and thunder; August 19, weather very dry since middle of July." After August 1, a careful meteorological record was kept by a daughter of Mr. Hatch, in accordance with the rules of the Signal Service, from which it appears that 3.46 inches of rain fell on 12 days during August and 2.5 inches on 6 days during September.

At Madison 7.02 inches of rain fell on 13 days in June and 1.81 inches in 7 days in July.

Plan of the work.—The questions to which answer was sought in the use of these materials, and the methods employed to answer them were:

I. The comparative efficacy of the three compounds named in preventing apple scab.

Two trees of the Fameuse variety were sprayed with each of the three compounds, and their crops compared with those of check trees not sprayed at all.

II. The efficacy of copper carbonate applied suspended in water, as compared with that dissolved in ammonia.

It was found in 1889 that the ammonia, unless very largely diluted, endangers the foliage, and gives the fruit a russety appearance. It also dissolves the arsenic of Paris green or London purple when used for the codling moth at the same spraying, and this indirectly causes injury to the foliage. To answer the second question, two Fameuse trees were sprayed with copper carbonate dissolved in ammonia and two others with the same material simply stirred in water, as we apply Paris green. The crops of these two pairs of trees were compared with each other, and also with those of the check trees.

III. The value of treatment previous to the opening of the flowers.

Two Fameuse trees were sprayed once with ammoniacal copper carbonate before bloom and three times after, and their crops compared with those of two other trees sprayed four times after bloom. The crops of the four trees were compared with those of check trees not sprayed. Also, two trees of the Canada peach variety were sprayed with suspended copper carbonate twice before bloom and twice after, and their crops compared with those of two others sprayed with the same four times after bloom, and also with those of check trees.

IV. The number of treatments necessary to secure the most beneficial results.

Two Fameuse trees were sprayed with ammoniacal copper carbonate 2, 4, 6, and 8 times respectively, and the crops of the different pairs compared with each other and with check trees not sprayed at all.

The strength at which the fungicides were used.—The copper carbonate was in every case of the precipitated form and when applied in the diluted ammoniacal solution was used at the rate of an ounce of the salt to 25 gallons of water. One ounce was dissolved in a quart of ammonia (strength 22° Baumé) and the solution added to the water just before the treatment at the rate named.

When the copper carbonate was applied in suspension an ounce was first well stirred in a small quantity of water and the mixture thus formed was added to 12½ gallons of water.

The sulphur powder was used according to the directions on the package, *i. e.*, 10 pounds were added to a barrel of water and allowed to stand a few hours before use. The yellow colored liquid resulting was employed without dilution. As the barrel became nearly empty it was again filled with water and the solution used as before.

The mixture No. 5 was used as suggested by you, viz, 12 ounces to 22 gallons of water in the first two treatments, but owing to injury to the foliage it was diluted one-third in the later sprayings.

The trees selected for the experiment were of medium size, and all promised a full crop of fruit, though as appears from the table on a succeeding page, all did not mature a full crop. None of the trees used in the experiment of 1889 were employed in the experiment here reported. The first treatment was given on May 5, and others were made May 13, 31, June 5, 16, 28, July 14, 25, August 6, 19, and September 2. Of course all the trees were not treated at all the sprayings. The treatment of June 5 was intended to supplement that of May 31, much rain having fallen between these dates. As the apples showed indications of maturity the entire crop on each of the trees selected for the experiment was gathered and assorted into three qualities as follows:

(1) Fruits quite free from scab.

(2) Fruits showing scab spots but not of sufficient size or number to distort the apples.

(3) Fruits more affected.

In assorting the crops only the scab was considered; size and insect injury being ignored. Some of the fruits placed in the first quality were badly distorted by insect injuries, and were very small in size. In like manner some fruits of comparatively large size were of necessity placed in the third quality.

The numerical data relating to the experiment are chiefly grouped together in the accompanying table but as this table is necessarily somewhat complicated the more important points brought out are graphically illustrated on succeeding pages.

Tree No.	Variety.	Sprayed with—	Number of times sprayed.*	Dates when sprayed.
1	Canada peach	Suspended copper carbonate.	2 before bloom; 2 after bloom.	May 5, 13, and 31, June 5.
2	....do	....do	....do	Do.
3	....do	....do	4	May 31, June 5,† 16, and 28, July 14.
4	....do	....do	4	Do.
5	....do	Check—not sprayed		
6	....do	....do		
7	Fameuse	Suspended copper carbonate.	6	May 31, June 5,† 16, and 28, July 14 and 25, Aug. 16.
8	....do	....do	6	Do.
9	....do	Ammoniacal copper carbonate.	6	Do.
10	....do	....do	6	Do.
11	....do	....do	2	May 31, June 5† and 28.
12	....do	....do	2	Do.
13	....do	....do	4	May 31, June 5,† 16, and 28, July 14
14	....do	....do	4	Do.
15	....do	....do	8	May 31, June 5,† 16, and 28, July 14 and 25, Aug. 6 and 19, Sept. 2.
16	....do	....do	8	Do.
17	....do	....do	1 before bloom; 3 after bloom.	May 7 and 31, June 5,† 16, and 28.
18	....do	....do	....do	Do.
19	....do	Bean's Sulphur Powder.	6	May 31, June 5,† 16, and 28, July 14 and 25, Aug. 6.
20	....do	....do	6	Do.
21	....do	Mixture No. 5	8	May 31, June 5,† 16, and 28, July 14 and 25, Aug. 6 and 19, Sept. 2.
22	....do	....do	8	Do.
23	....do	Check—not sprayed		
24	....do			

* Always sprayed *after the petals had fallen* unless otherwise stated.
† The spraying of June 5 was intended to supplement that of May 31.

Tree No.	Variety.	Number of fruits.	Per cent of fruits in—			Average for the two trees; per cent of fruits in—			Weights of 100 fruits.		
			First quality.	Second quality.	Third quality.	First quality.	Second quality.	Third quality.	First quality.	Second quality.	Third quality.
									Ozs.	*Ozs.*	*Ozs.*
1	Canada peach	257	16.34	77.43	6.23						
2	....do	211	6.64	76.30	17.06	11.49	76.86	11.14			
3	....do	175	5.71	72.57	21.72						
4	....do	138	7.25	45.65	47.10	6.48	59.11	34.41			
5	....do	238	2.94	61.35	35.71						
6	....do	865	0.36	68.98	30.66	1.65	65.16	33.18			
7	Fameuse	633	3.79	41.71	54.38				313	275	259
8	....do	632	1.58	40.98	57.44	2.68	41.34	55.91	300	286	199
9	....do	1,027	2.82	32.91	64.27				300	281	202
10	....do	850	8.82	35.30	55.88	5.82	34.10	60.07	262	242	181
11	....do	906	1.55	25.94	72.51				279	259	186
12	....do	1,161	3.16	37.15	59.69	2.35	31.54	66.10	154	243	172
13	....do	1,042	5.57	42.23	52.20				288	257	178
14	....do	968	5.58	43.80	50.62	5.57	43.01	51.41	280	254	182
15	....do	1,746	4.07	44.67	51.26				280	258	176
16	....do	581	7.84	45.32	46.84	5.95	44.99	49.05	288	267	198
17	....do	912	20.61	56.47	22.92				241	272	217
18	....do	1,332	25.60	47.22	27.18	23.10	51.84	25.05	283	255	198
19	....do	13,59	1.18	23.18	75.64				256	254	182
20	....do	707	1.82	29.00	69.18	1.50	26.09	72.41	300	290	203
21	....do	1,096	18.70	52.56	28.74				221	217	166
22	....do	719	9.04	50.77	40.19	13.87	51.66	34.46	245	231	186
23	....do	258	1.16	22.87	75.97				300	265	182
24	....do	762	3.59	42.82	53.59	2.37	32.84	64.78	307	259	189

The comparative efficacy of copper carbonate, sulphur powder, and Mixture No. 5 in preventing Apple Scab.—This will appear by consulting Fig. 1 and Pl. IV, Fig. 5. In the experiment the trees were sprayed six times with the sulphur powder and eight times with the Mixture No. 5. We therefore compare those treated with the former with the trees sprayed six times with the ammoniacal copper carbonate, and those treated with the latter with those sprayed eight times with the ammoniacal copper carbonate. In Fig. 4, Pl. IV, is shown the proportion of fruits in each of the three qualities from the trees sprayed eight times with the Mixture No. 5, and the copper carbonate as compared with those from the untreated trees.

The white portion represents the first quality, the diagonal lines the second, and the black portion the third quality.

From this it appears that the Mixture No. 5 was considerably the more efficacious. In Fig. 5 we compare the effect of six treatments with the sulphur powder and ammoniacal copper carbonate with that of the check trees, from which it would seem that the sulphur powder actually appeared to increase the amount of scab. It is more probable, however, that the trees treated with this material were from some cause more than usually affected with the disease which the sulphur compound, possibly owing to its ready solubility which caused it to be easily washed off by the rains, entirely failed to prevent.

The efficacy of copper carbonate suspended in water as compared with that dissolved in ammonia.—From Fig. 6 it is evident that the results from six sprayings of copper carbonate applied in suspension and in ammoniacal solution were very meager in both cases. The first and third qualities were larger in the case of the solution, while the second was larger in that of the suspended copper carbonate. If the results may be assumed to teach anything it would seem that there was little difference in the efficacy of the two methods of application.

From Fig. 8, in which the data represent the results of spraying the Canada peach apple with suspended copper carbonate before and after bloom, the benefit from the treatment before bloom is very perceptible, which indicates that this method of using copper carbonate is capable of giving good results.

The value of treatment previous to the opening of the flowers.—From Fig. 7 it is evident that one treatment of the Fameuse apple before the flower had opened with three treatments after the petals had fallen was much more efficacious in preventing the scab than four treatments made after the falling of the petals, a result which is corroborated in Fig. 8, which represents the results secured in treating two trees of the Canada Peach twice before bloom and twice after, as compared with four treatments after bloom.

The number of treatments necessary to secure the most beneficial results.—From Fig. 9 it appears that eight treatments gave only slightly better results than four, but that four gave considerably better than two. The first two treatments succeeding the falling of the petals (made May 31 and June 16), it would appear, gave absolutely no results, while the two made June 28 and July 14 seem to have proved beneficial. The excessive rains during the early part of June doubtless washed off the fungicides from the foliage before they had time to act, and at the same time promoted the growth of the fungus. The lesson suggested is that treatments made after midsummer are of doubtful value.

To what extent does the scab reduce the size of the fruit?—As will appear from the table on a preceding page all of the fruits of the Fameuse apple in the different qualities were weighed. These weights furnish data from which we may compute with a fair degree of accuracy the influence of the scab in reducing the size of the apples. As only the scab was considered in assorting, we are perhaps justified in assuming that the reduced size of the scabby fruits was due to the exhaustive action of the fungus, and that had all the apples been free from the disease all would have been as large as those of the first quality. From the data it appears that, averaging the crop from all of the Fameuse trees, the fruits of the first quality weighed 262 ounces per hun-

dred, those of the second 258, and those of the third 189. The average weight of the fruits in the different qualities appears below in Fig. 2.

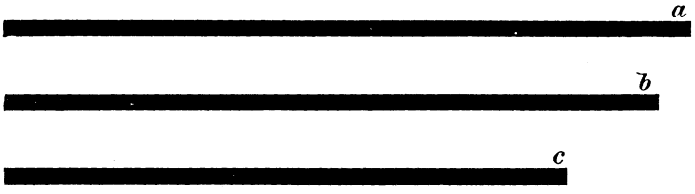

FIG. 2.—*a*, first quality; *b*, second quality; *c*, third quality.

Had all the fruits from the eighteen Fameuse trees been equal in size to those of the first quality the actual increase of the crop would have been a trifle over 413 pounds, or more than 17.8 per cent of the entire yield of apples. This, it should be remembered, only represents the effect of the scab in reducing the size of the fruits actually developed. It does not take into account the injury to the appearance of these fruits, the fruits that were prevented from developing, nor the injury wrought by the fungus to the vigor of the tree.

Cost of the treatments.—From the materials and the time consumed in the treatments, counting copper carbonate at 50 cents per pound, ammonia $1.50 per gallon, and labor 15 cents per hour, I have computed the cost of the treatments with these materials approximately as follows:

Cost for spraying one tree once with ammoniacal copper carbonate:

For materials	$.022
For labor	.0375
Total	.0595

Or, including labor of preparing, about 6 cents.

Suspended copper carbonate, using double the amount as in the above:

For materials	$.0039
For labor	.0375
Total	.0414

Or, including labor of preparing, about 4.2 cents.

These prices could be considerably reduced by purchasing the materials in quantity and making the applications with a larger force pump.

I have not been informed as to the cost of the sulphur powder or Mixture No. 5.*

Recapitulation.—The results of the experiment in the treatment of apple scab, described in the foregoing pages, suggest the following conclusions:

I. That in seasons of excessive rains in early summer the scab on badly infested trees can not be wholly prevented by the treatments given in this experiment.

II. That of the substances tested the mixture of ammonium carbonate and ammoniated copper sulphate (designated as Mixture No. 5)† was most efficient.

III. That the precipitated copper carbonate applied stirred in water, as we use Paris green, is nearly or quite as efficient as when one-half the amount was applied dissolved in ammonia, a point which, if confirmed by further trials, is important, as it will render possible the use of Paris green for the codling moth at the same spraying with the fungicide.

IV. That early treatments, and especially at least one treatment previous to the opening of the flowers, is extremely important.

* I mention, on the authority of Dr. S. M. Babcock, that this material is, when dissolved in water, very similar in chemical composition to the ammoniacal copper carbonate. On adding water to the mixture a chemical change takes place, the result of which is the formation of copper carbonate dissolved in ammonia and ammonium sulphate.

† Mixture No. 5 costs practically the same as the ammoniacal solution.

V. That sprayings after midsummer are at best of doubtful value.

VI. That on trees badly infested with scab the fruits that develop may be so far reduced in size by the fungus as to diminish the crop nearly 20 per cent; but this is doubtless but a small part of the injury actually produced.

In conclusion, I would recommend that in future experiments a larger number of trees be employed as duplicates. A study of the results secured in this experiment, as well as those gained in the trial of 1889, makes it clear that two trees are not always sufficient to furnish data for drawing definite conclusions.

EXPERIMENTS IN THE TREATMENT OF THE SEPTORIA OF THE RASPBERRY AND BLACKBERRY.

The fungicides tested for the Septoria of the raspberry and blackberry were:

I. Bordeaux mixture.

II. Ammoniacal copper carbonate.

III. The mixture of ammoniated copper sulphate and ammonium carbonate, used for the apple scab as Mixture No. 5.

The Bordeaux mixture was made by slacking 6 pounds of lime in one vessel, and dissolving 4 pounds of copper sulphate in another, uniting the contents of the two vessels on the cooling of the lime and diluting the whole with water to 22 gallons.

After the first two treatments, the Bordeaux mixture was diluted one-third, as the foliage showed indications of injury.

The other two fungicides were used in the first two treatments of the strength noted in the experiment for apple scab, viz, an ounce of copper carbonate dissolved in a quart of ammonia, and the solution diluted with 25 gallons of water; 12 ounces of the mixture No. 5 dissolved in 22 gallons of water. After the second spraying, the solution of mixture No. 5 was diluted one-third for the reason named above.

The varieties of raspberry selected for the experiment were Cuthbert for red, and Tyler and Gregg for black; those of the blackberry were Stone's hardy and Ancient Briton. All were growing in somewhat dense rows, and at the time of the first spraying, May 31, presented a thrifty appearance, and gave promise of a good crop of berries. At this time the leaves were nearly full grown and the flower buds though visible had not yet opened. Forty feet of row of each variety selected for the experiment was treated at the different sprayings with each of the fungicides named. Treatments were given on May 31, June 5, 18, 28, July 7 and 14. In the treatment of July 28, the Tyler and Cuthbert raspberries were omitted, as there were unmistakable indications of injury to the foliage. In the treatment of July 7 and 14 all of the raspberries were omitted, as the fruit was beginning to ripen.

During my visit to Mr. Hatch's place, on July 24, it was evident that all of the fungicides used had injured the foliage to some extent on both the raspberry and blackberry. The injury seemed most pronounced in the case of Mixture No. 5, and least in that of ammoniacal copper carbonate. The foliage of the black cap raspberries showed more injury than that of the red, and there were indications that the crop would be injured or at least retarded. It was also evident that the Bordeaux mixture, on account of its adherence to the fruit, is very poorly adapted for use upon these crops. The Septoria was visible at this time on untreated rows of both the raspberry and blackberry. Where the treatments had been given, the blackness of the foliage rendered it difficult to decide to what extent the Septoria was active.

The crop on all of the treated plants, except those of the Tyler raspberry,* and of the plants set off as checks was measured by Mr. Hatch at each picking.

As the best means of determining the results of the treatments upon the yield of berries, the bearing wood from each section of row devoted to the experiment, including the checks, was cut out after the harvest, bound into bundles and weighed. The computations rendered possible from the data thus secured appear in the following table:

* The fruit and foliage of the Tyler raspberry were practically destroyed by the fungicides.

Table showing the results of treatment of raspberry and blackberry for Septoria.

	Sprayed with—	Yield of berries.	Weight of bearing wood.	Calculated yield on 100 pounds of bearing wood.
Raspberry:		*Quarts.*	*Pounds.*	*Pounds.*
Cuthbert (sprayed 3 times)	Bordeaux mixture	3½	10.5	33.33
	Copper carbonate	14	15.5	90.32
	Mixture No. 5	16¼	22	73.86
	Check	21¼	14.5	146.55
Gregg (sprayed 4 times)	Bordeaux mixture	2.4	12.5	19.2
	Copper carbonate	4⅛	16	29.12
	Mixture No. 5	3⅜	13	28.84
	Check not sprayed	16¼	15.3	106.21
Blackberry:				
Stone's Hardy (sprayed 6 times)	Bordeaux mixture	17	19.5	87.02
	Copper carbonate	19¼	18	106.94
	Mixture No. 5	14½	14	101.79
	Check	13⅜	16.5	83.33
Ancient Briton (sprayed 6 times)	Bordeaux mixture	10⅜	8.25	130.3
	Copper carbonate	17¾	8	221.87
	Mixture No. 5	16¼	8.125	200
	Check not sprayed	18¼	9.5	205.48

From the table it would appear that the yield of raspberries was seriously injured by all of the treatments, and especially by the Bordeaux mixture and Mixture No. 5, but that the crop of blackberries was somewhat improved by the use of the copper carbonate. In the Stone's Hardy, the yield seems to have suffered from none of the treatments, and to have been improved by both the copper carbonate and Mixture No. 5, while in the Ancient Briton the crop seems to have been injured by the Bordeaux mixture.

The cost of making the individual treatments in the experiment upon the raspberry and blackberry would not differ much from that of spraying one apple tree with each of the fungicides. An estimate of the cost in the case of the copper carbonate may therefore be made by referring to the paragraph giving the cost of the apple sprayings. The cost of the Bordeaux mixture would be slightly greater than that of the ammoniacal copper carbonate.

From this experiment it is evident—(1) That the foliage of the raspberry is delicate, and can not endure applications of a corrosive nature; (2) that the foliage of the blackberry though more resistant than that of the raspberry is more susceptible to injury than that of the apple; (3) that none of the treatments given are to be recommended for the raspberry, and that of the materials used only the copper carbonate solution can be pronounced beneficial in the case of the blackberry.

EXPERIMENT IN TREATING THE POTATO ROT.

The only fungicide tested in this experiment was the Bordeaux mixture prepared as noted in the preceding article. The plat selected for the experiment included about half an acre of ground nearly in the form of a square, and was planted with snowflake potatoes May 31, the seed being placed in hills 3½ feet apart each way.

Five rows extending through the center of the plat in each direction were staked off as a check area, the four corner plats thus separated being subjected to the treatment. The SW. plat was treated with the Bordeaux mixture at its full strength; for the NE. plat the mixture was diluted about one-fourth; for the SE. plat about one-third, and for the NW. plat about one-half.

The first treatment was given July 3d, at which time the plants were 3 to 15 inches high, and apparently entirely healthy. Other treatments were given July 14 and 25, August 6 and 19, and September 2.

More or less of the mixture was visible upon the vines at all times after the first spraying until the crop was harvested. At the time of the fifth spraying (August 19) it was evident that the treatment was bearing fruit, as the foliage of the check rows

was turning yellow and in spots becoming brown and apparently dying, while that of the treated portions was still fresh and green. At the last spraying (September 2) the effect of the treatment was still more marked, the vines in the check rows being mostly dead or severely blighted, while very little of the blight was visible on the treated plats.

During my visit to Mr. Hatch's place in the latter part of September, the check rows were conspicuous by their brown and dry appearance at a distance of several rods from the field, while the vines in the treated areas were still for the most part green and growing. A frost occurred September 28, which destroyed most of the surviving foliage. October 9 to 15 the potatoes in the various plats were dug, assorted, counted, measured, and weighed. The numerical data appear in the following table. The results of the treatment appear more clearly from the graphic diagram (Fig. 3), in which the white portion represents the yield of merchantable potatoes, and the diagonal lines that of the small potatoes.

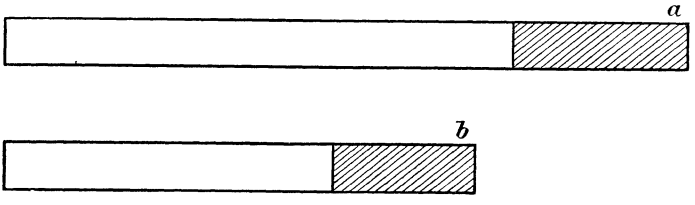

FIG. 3.—*a*, after six treatments; *b*, not treated.

Plat.	No. of hills.	Merchantable yield.		Total yield.		Yields calculated to a uniform number of hills.			
						Merchantable.		Total.	
		No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.
			Pounds.		*Pounds.*		*Pounds.*		*Pounds.*
Northeast corner	321	2,255	835	6,815	1,133	2,669	988	8,068	1,310
Northwest corner	287	2,530	871	6,455	1,102	3,350	1,049	8,547	1,459
Southeast corner	340	2,176	903	7,462	1,320	2,432	1,009	8,340	1,475
Southwest corner	343	3,075	1,127	6,905	1,367	3,407	1,249	7,650	1,514
Check	380	2,125	698	6,200	1,000	2,125	698	6,200	1,000

The unequal number of hills in the different plats arose from two causes, viz, the whole area was not quite regular in outline, and as the ground was a little sloping, the heavy June rains washed out some hills in places. The numbers recorded in the table represent the hills that matured their crop, as determined by counting before the potatoes were dug.

As the check rows traversed the whole planted area in both directions, we are justified in assuming that they represented an average of the whole plat so far as the conditions of soil and culture were concerned, and that any difference in the yield of these rows, and that of the average of the four treated plats, when calculated to a given number of hills was due to the treatment. In other words, had each of the four treated plats contained the same number of hills as the check rows, the aggregate yield from them would have been, without treatment, approximately four times as much as that from the check rows. Considering the yield of merchantable potatoes, then, the four treated plats would have yielded without the treatment 4 × 698, or 2,792 pounds, whereas they actually yielded 4,295 pounds, or an increase, presumably due to the treatment, of 1,503 pounds, a fraction over 25 bushels. From the figures, it would appear that the applications to the southwest plat, in which the fungicide was used at its full strength, were most effectual, and that for the potato, the Bordeaux mixture should not be diluted.

The cost of the treatment was approximately as follows:

69 pounds copper sulphate, at 9 cents	$6.21
24 hours' labor, at 15 cents	3.60
Lime and labor of preparation	.50
Total	10.31

from which it appears that the treatment, though made with a small hand force pump, and in the most thorough manner, was more than compensated for by the increased yield secured.

It should be added that none of the potatoes were decayed at the time of digging, and that there were no indications that the blight which so injuriously affected the foliage of potatoes the past season on the check rows of our experimental plat, and throughout southern Wisconsin, was connected in any way with the potato-rot fungus, *Phytophthora infestans*. But whatever the affecting disease was, it is evident that the treatment proved a remedy for it.

Mr. Hatch states that the Colorado potato beetle *Doryphora decemlineata* did not attack the potato plants in the treated plats, an additional point of some value in favor of the treatment.

DESCRIPTION OF PLATE.

PLATE IV.

Fig. 4. The value of mixture No. 5, as compared with that of ammoniacal copper carbonate.
- *a*, mixture No. 5, sprayed eight times.
- *b*, ammoniacal copper carbonate, sprayed eight times.
- *c*, check, not sprayed.

Fig. 5. The value of ammoniacal copper carbonate as compared with Bean's sulphur powder.
- *a*, ammoniacal copper carbonate, sprayed six times.
- *b*, Bean's sulphur powder, sprayed six times.
- *c*, check, not sprayed.

Fig. 6. The value of copper carbonate suspended in water as compared with that dissolved in ammonia.
- *a*, suspended copper carbonate, sprayed six times.
- *b*, ammoniacal copper carbonate, sprayed six times.
- *c*, check, not sprayed.

Fig. 7. The effect of spraying before bloom—Fameuse.
- *a*, sprayed once before bloom, three times after.
- *b*, sprayed four times after petals had fallen.
- *c*, check, not sprayed.

Fig. 8. The effect of spraying before bloom—Canada Peach.
- *a*, sprayed twice before bloom, and twice after.
- *b*, sprayed four times after bloom.
- *c*, check, not sprayed.

Fig. 9. *a*, eight treatments with ammoniacal copper carbonate.
- *b*, six treatments with ammoniacal copper carbonate.
- *c*, four treatments with ammoniacal copper carbonate.
- *d*, two treatments with ammoniacal copper carbonate.
- *e*, no treatment.

Additional Notes by Mr. Hatch.

EXPERIMENTS IN TREATING APPLE SCAB.

(*Fusicladium dendriticum.*)

It is my opinion that the first spraying for the apple scab should be made much earlier than the time usually selected for the first spraying for the codling moth. The foliage is then pretty well formed, and the past season we found well developed scab spots upon the leaves at that time. The few scab spots found later in the season that appeared to have been killed by the treatment warrants the conclusion that the chief benefit of spraying comes through the destruction of the spores that have gained lodgment upon the fruit and foliage. The results in the case of the trees treated before blooming also points in this direction. I think it possible that a treatment before the buds have commenced to expand would be productive of much good.

The extremely heavy rains of June and the first part of July rendered the season very unfavorable for the work and resulted in loss of the benefits of spraying my main orchards for both apple scab and insects. Still, by persistent effort I think we have some valuable results. At least we have done all possible to make them successful, and our thanks are due to Professor Goff for his aid at various stages of the work. My loss from apple scab has been very serious, not only in fruit but also in foliage, and the magnitude of its injury warrants still greater efforts in combatting it.

We found Mixture No. 5 very persistent upon the foliage, but apparently too strong in ammonia. Its caustic effects were so apparent that for some of the later sprayings we reduced the quantity one-third. The solution of carbonate of copper, although diluted 100 parts with water, had similar effects, and I would suggest that it may possibly be found equally efficient if diluted even 200 times. We used strong ammonia (supposed to be 22° Baumé) to make a saturated solution (about 1 ounce to 1 quart). In using carbonate of copper in water alone I think we used too little. There would have been no harm to the foliage if used several times as strong, nor indeed is it likely to prove injurious in any degree.

The treatment in the case of the blackberry and raspberry was for *Septoria rubi*, a small fungus causing the foliage to turn yellow, wither, and fall before the fruit matures. Here again earlier treatment seems to be advisable. The first spraying was when leaves were about full grown. At this time Septoria showed plainly on the leaves, and it is our opinion that preventive treatment is more desirable than curative. The first Bordeaux mixture used was made with 6 pounds of copper sulphate and 4 pounds of lime. This injured the foliage so much that we reduced it with water one-third, and afterwards used 6 pounds of lime in place of 4. The other fungicides also proved injurious to the leaves, and we concluded that the black raspberries especially are very tender in foliage. The Bordeaux mixture proved especially bad, not only in injury to the foliage, but also in adhering to the fruit so as to make it unfit for use. It should be mentioned that the raspberries treated were each side of a row of blackberries that were last year destroyed by the orange rust. Still no rust was visible this year on either the raspberry or blackberry bushes that sprouted where the row was removed. The loss by Septoria this season has been quite large.

THE POTATO EXPERIMENT.

Rot has not been prevalent here for a few years. In order to secure its development for treatment we ordered a barrel of seed from Ohio, where rot was plenty last year, but failed to secure any affected potatoes. We then planted with such seed as we had, mostly Snowflakes, with a few mixed kinds. To still further assure rot we planted late, May 31, and supplemented 4 rows along one side of the plat which we covered with a fork full of sheep manure in each hill. The heavy rains not only washed out some of the potatoes, but so compacted the soil as to make them very slow in coming up and getting a start. The last of July and the month of August were extremely dry and no rot appeared. Even the manured rows were sound and

good, no Phytophthora being visible anywhere. There was, however, a blight of the foliage that has proved very general and widespread throughout all this region. The leaves turned yellow in spots, then brown, and the entire vines died long before the growing season was completed. The check rows in the experimental plat and my own potatoes elsewhere on my farm were all seriously affected with this blight. By the first of September this was so emphatic that the check rows were easily selected from the plat, the treated vines showing mostly bright and green when frost came. Still there was an occasional hill among the treated vines showing the same trouble as the untreated, but not in so large a degree.

We had expected to use our field pump in a large barrel mounted on farm trucks with the Vermorel nozzle attached to the hose, but found that we could not go over the plat and make the turns with the team without running into the potatoes and injuring them. So we abandoned its use and did the entire work by hand with our Nixon Climax pump, using a No. 3 Nixon nozzle. We overcame the difficulty of clogging by having a piece of brass wire strainer cloth soldered over the lower end of the suction pipe. This had a mesh finer than the orifice of the nozzle and was a complete remedy for clogging, not only in using the Bordeaux mixture, but also in all other spraying done by us.

Another variation we made was in using the Bordeaux mixture. We hauled out for each treatment a barrel containing 12 pounds each of copper sulphate and lime and 44 gallons of water properly mixed to make the regular Bordeaux mixture. We also took another barrel of clear water. At the beginning we stirred the mixture, allowed it to settle a minute, and took out two or three pailfuls to use. After using enough for the southwest corner, clear water was added to the large barrel, and so on until the plat was gone over, 70 to 75 gallons in all being used. This would give about the following strength nominally to each plat: Southwest, full strength; southeast, two-thirds; northeast, three-fourths; northwest, one-half. There was, however, about the same appearance in the consistency of the liquid used for each plat on account of the sediment in each lot being about all the water would carry, and the appearance of the vines after spraying was the same in each plat. From the time of the first spraying the application was always more or less visible. I thought there was a difference in the vigor of the vines in favor of the northeast corner, but suppose the figures as tabulated by Professor Goff will show this matter clearly. At any rate I venture the opinion that it may be well to experiment with Bordeaux mixture in a more diluted form than the regular formula.

Another apparent result of the spraying was in regard to the Colorado potato beetle. I found it necessary to go over the check rows with London purple the second time, but the treated part was almost entirely free from them. It would thus appear that where the mixture is used for rot and blight it may also be efficient as an insecticide.

DISEASES OF THE ORANGE IN FLORIDA.*

By LUCIEN M. UNDERWOOD.

The following notes on the diseases of the orange in Florida were made during a visit to that State during the months of February, March, and April of the present year (1891). They consist simply of the results of observations in the field and evidence collected from intelligent growers in various portions of the State. The orange groves and methods of cultivation and treatment were observed in the following counties: Brevard, Citrus, Hernando, Lake, Manatee, Marion, Orange,

* Professor Underwood collected the information embodied in this report while acting as special agent for the Division of Vegetable Pathology.—[B. T. G.]